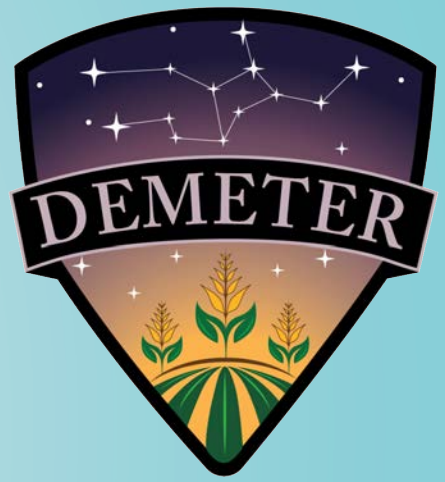
ESTF2020

# DEMETER – IIP
# DEMonstrating the Emerging Technology for measuring the Earth's Radiation




Presenter: Anum Ashraf

PI: Anum Ashraf

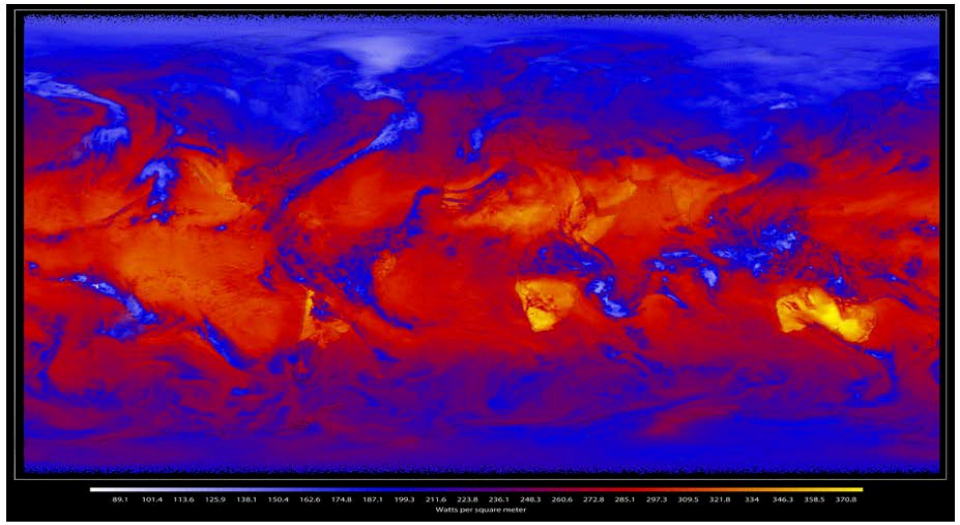
Team Members: Kory Priestley, Mohan Shankar, Alex Halterman, J.R. Mahan, Talbot Jaeger

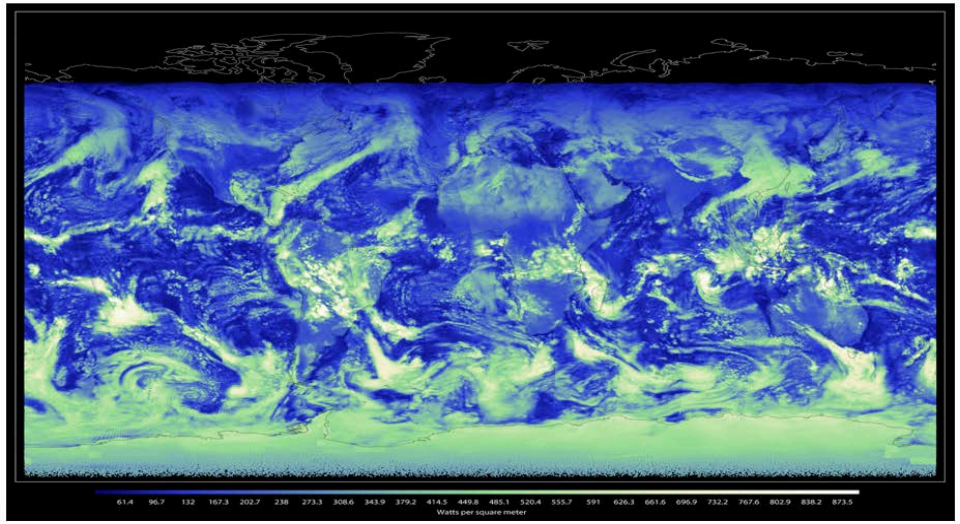
Program: Earth Radiation

QUARTUS ENGINEERING NovaWurks VT SSAI

# Earth Radiation Budget Measurement

- ERB represents a balance between incoming solar radiation reaching the TOA with outgoing reflected solar and thermal radiant energy emitted by the Earth-atmosphere system.
- Long-term, sustained, and accurate climate observations are essential as acknowledged in multiple national and international community reports and publications.
- Since 2000 CERES project has provided the continuous climate data record aboard flagship missions (Terra, Aqua, S-NPP and NOAA-20).
- Overlap in observations between ERB sensors is required to tie the measurements to a common radiometric scale and for data continuity.
- The current approach relies on flying ERB instruments as hosted payloads on large and expensive flagship missions.



# Solution

- DEMETER is a **“right size”, free-flying** sensorcraft solution and a revolutionary approach for making an enhanced Fundamental Climate Data Record (ERB-FCDR) from Low Earth Orbit as its predecessor CERES
- The sensorcraft approach integrates:
  - A non-scanning optical module
  - A two-dimensional detector array
  - Sensor payload elements with a cellular satlet craft/platform
- Reduces mass, power, and cost, by an order of magnitude over current state-of-the-art techniques.
- Eliminates the classic boundaries of a payload and spacecraft, replacing it with an integrated system that shares resources, thereby eliminating duplicity while increasing redundancy in a small package.

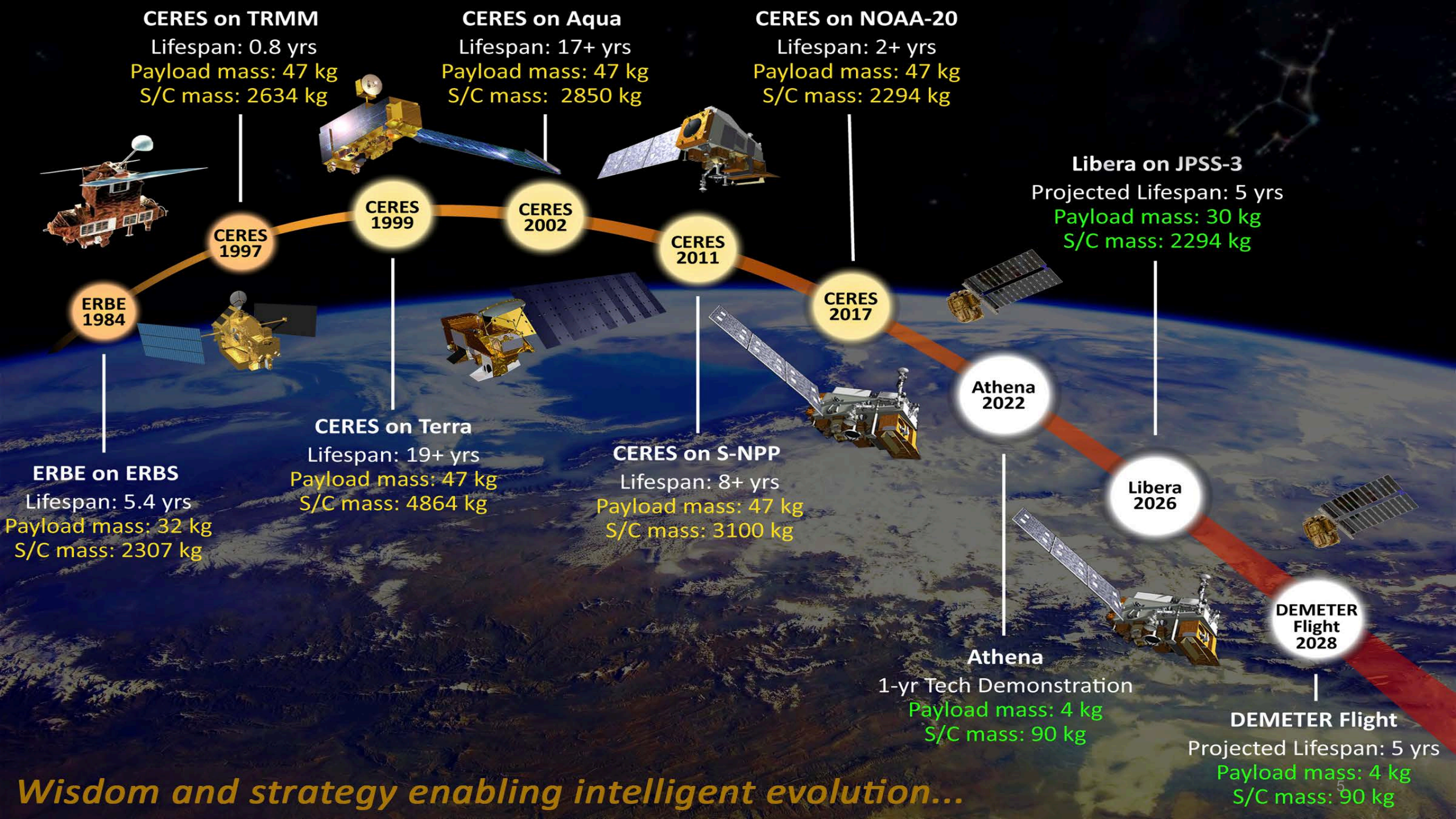
# Solution

**DEMETER Goals**

1. Preserve Continuity
2. Expand Capability

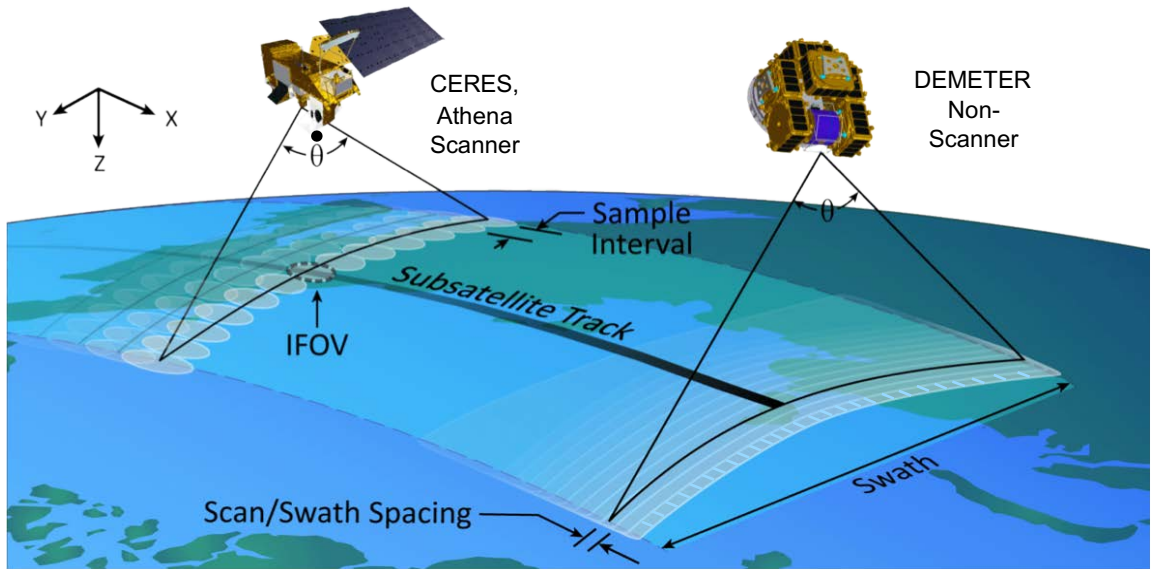
**Means to the Goals**

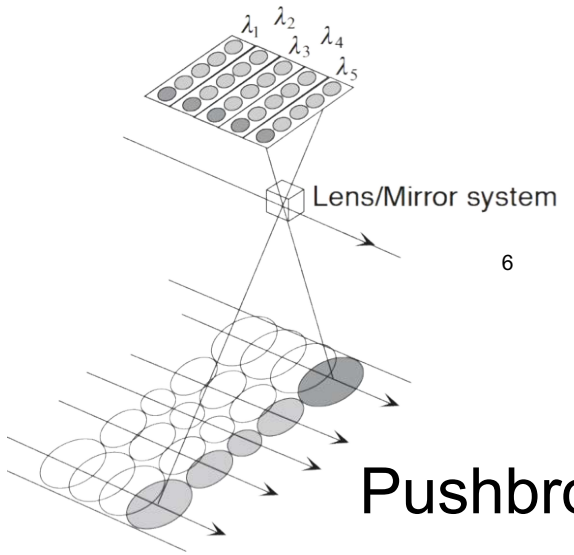
1. Reducing the IFOV by a factor of ~10
2. Improving sampling of the Earth's diurnal cycle
3. Reducing the risk of a gap in the multi-decadal ERB-FCDR
4. In-situ processing capability
5. Enabling future technology infusion via a cellular/configurable architecture


CERES on TRMM
Lifespan: 0.8 yrs
Payload mass: 47 kg
S/C mass: 2634 kg
CERES on Aqua
Lifespan: 17+ yrs
Payload mass: 47 kg
S/C mass: 2850 kg
CERES on NOAA-20
Lifespan: 2+ yrs
Payload mass: 47 kg
S/C mass: 2294 kg
Libera on JPSS-3
Projected Lifespan: 5 yrs
Payload mass: 30 kg
S/C mass: 2294 kg
ERBE 1984
CERES 1997
CERES 1999
CERES 2002
CERES 2011
CERES 2017
Athena 2022
Libera 2026
DEMETER Flight 2028
ERBE on ERBS
Lifespan: 5.4 yrs
Payload mass: 32 kg
S/C mass: 2307 kg
CERES on Terra
Lifespan: 19+ yrs
Payload mass: 47 kg
S/C mass: 4864 kg
CERES on S-NPP
Lifespan: 8+ yrs
Payload mass: 47 kg
S/C mass: 3100 kg
Athena
1-yr Tech Demonstration
Payload mass: 4 kg
S/C mass: 90 kg
DEMETER Flight
Projected Lifespan: 5 yrs
Payload mass: 4 kg
S/C mass: 90 kg
Wisdom and strategy enabling intelligent evolution...

# Technical Details

- Non-scanning, wide-field-angle radiometer to measure limb-to-limb TOA radiances, while integrated with a NovaWurks Hyper  Integrated Satlet (HISat) sensorcraft
- HISat features include:
  - Modular/reconfigurable architecture allows for technology infusion
  - Rightsizing to the measurement
- NovaWurks is the industry leader for  conformable spacecraft architectures
- Demonstrated on-orbit pointing control and radiation hardness

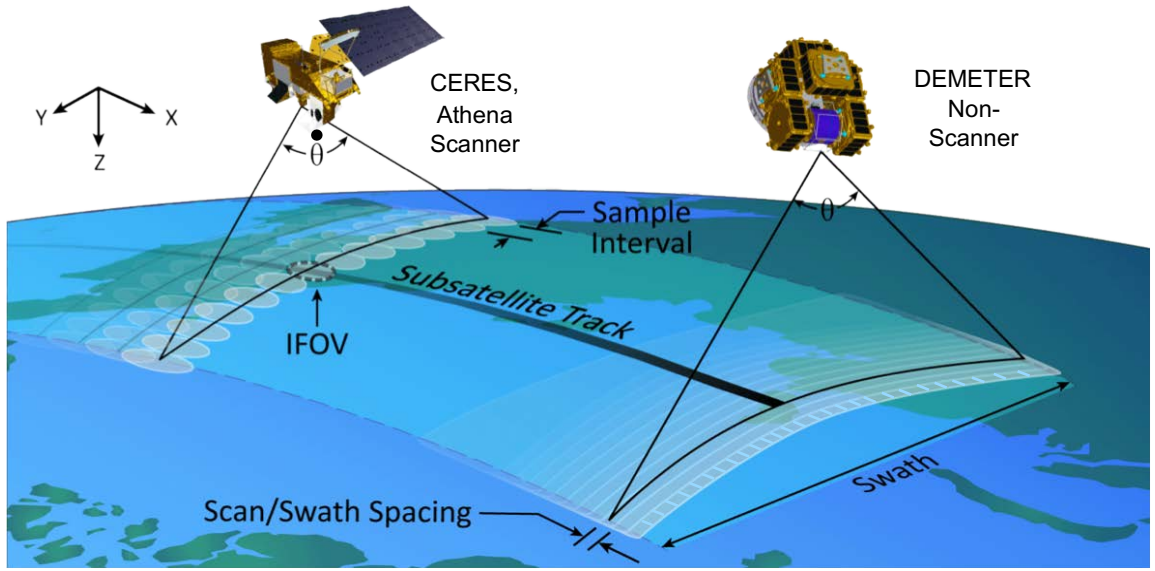


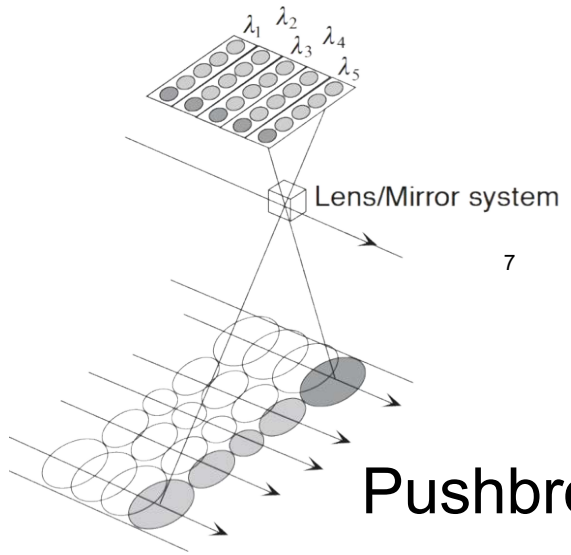




Pushbroom sensor

# Technical Details

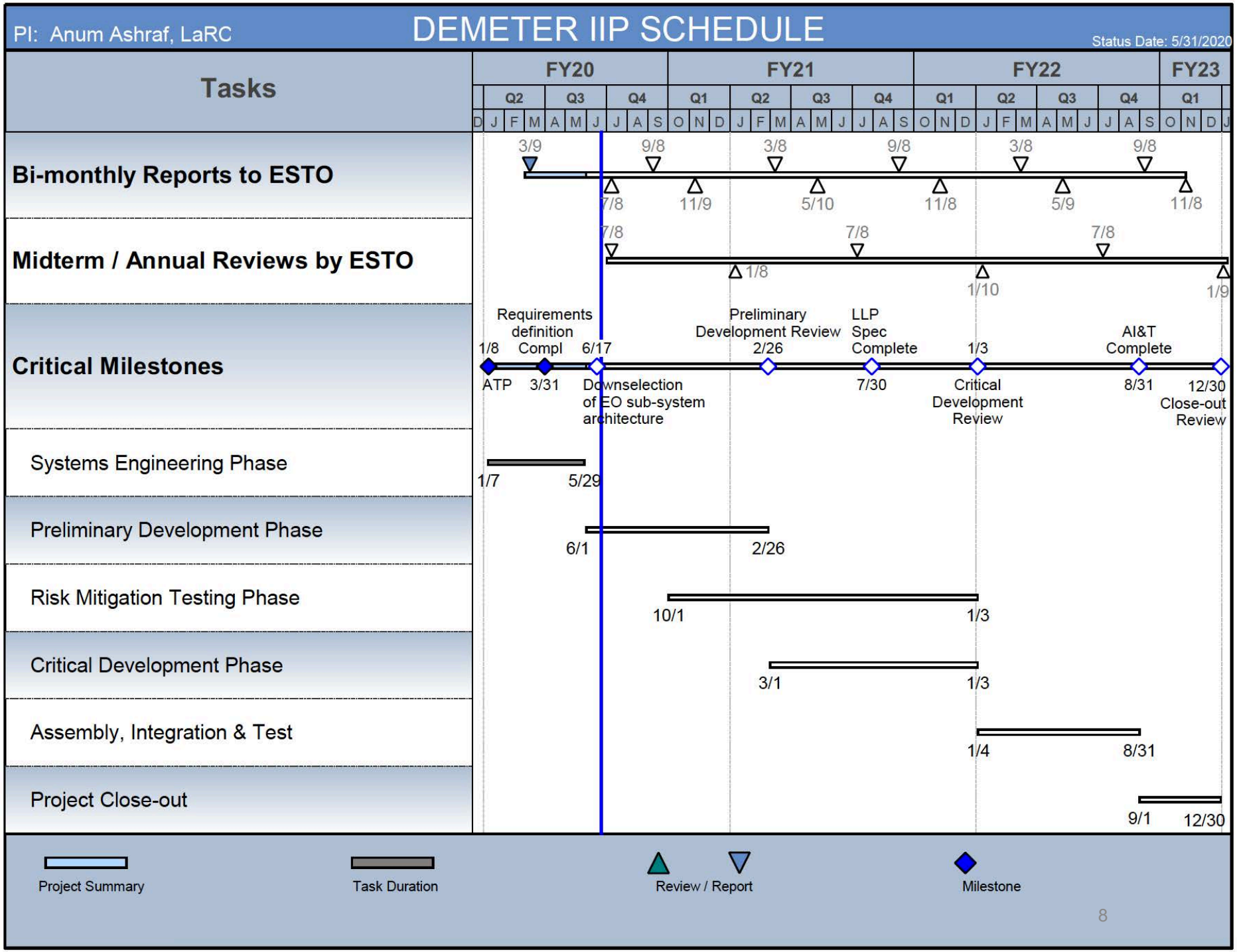
- The two-dimensional detector array oriented perpendicular to the satellite ground track will simultaneously collects a single limb-to-limb swath of <10 km IFOV's.
- Each of the rows on the detector collect unique information, either spectral or relating to the polarization content of the incoming light.
- Successive readouts of the array represent consecutive swaths providing the necessary spatial coverage of the TOA radiation fields for nominal observations.




Pushbroom sensor

# Next Steps


PI: Anum Ashraf, LaRC
DEMETER IIP SCHEDULE
Status Date: 5/31/2020
Tasks
FY20
FY21
FY22
FY23
Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1
D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J
Bi-monthly Reports to ESTO
3/9 9/8 3/8 9/8 3/8 9/8
7/8 11/9 5/10 11/8 5/9 11/8
Midterm / Annual Reviews by ESTO
7/8 7/8 7/8
1/8 1/10 1/9
Critical Milestones
Requirements definition Compl
1/8
ATP
3/31
6/17
Downselection of EO sub-system architecture
Preliminary Development Review
2/26
LLP Spec Complete
7/30
1/3
Critical Development Review
AI&T Complete
8/31
12/30
Close-out Review
Systems Engineering Phase
1/7 5/29
Preliminary Development Phase
6/1 2/26
Risk Mitigation Testing Phase
10/1 1/3
Critical Development Phase
3/1 1/3
Assembly, Integration & Test
1/4 8/31
Project Close-out
9/1 12/30
Project Summary
Task Duration
Review / Report
Milestone

# Back Up Slides

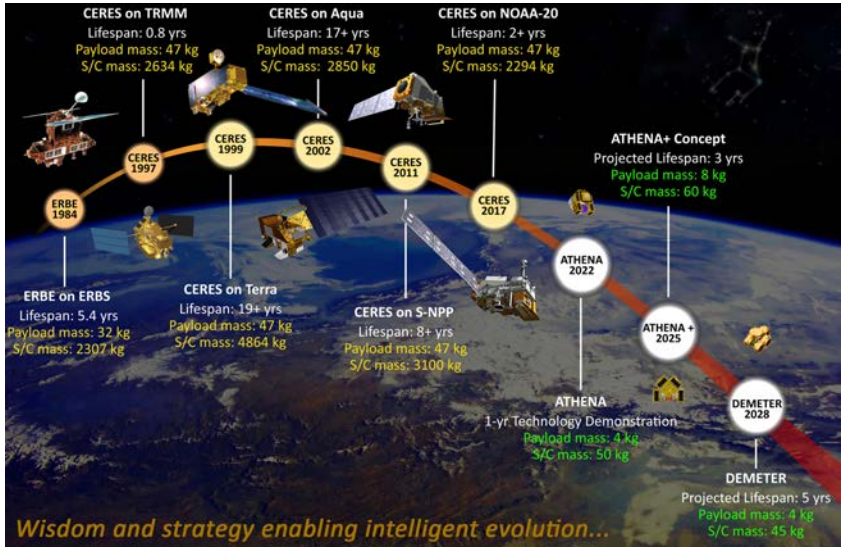
# DEMETER

## DEMonstrating the Emerging Technology for measuring the Earth's Radiation

PI: Dr. Anum Ashraf, LaRC

## Objective

- Develop a sensorcraft that demonstrates a **game-changing** approach for measuring the Earth Radiation Budget Fundamental Climate Data Record.
- Exploit the science capability and greatly exceed data quality of current measurement by:
  - Increasing spatial resolution by factor of 10
  - Incorporating **intelligent** on-board data processing
- **Innovative** and **integrated** solution that reduces mass, power, risk, and cost, by an order of magnitude over current state-of-the-art techniques.
- Drastically reduced form-factor enables low cost flight opportunities providing more complete global diurnal sampling of radiation fields and significant risk reduction of a gap in the multi-decadal climate data record.




## Approach

- Leverage 100+ years of direct experience to pro-actively influence the design and address trades involved in an integrated and intelligent manner
- Design and build a non-scanning wide-angle telescope that reduces IFOV and increases spatial resolution
- Build and test a technology demonstration unit consisting of the wide-angle telescope integrated with sensorcraft elements

**Co-I's:** Kory Priestley, Wenying Su, Seiji Kato, Dave Doelling, Paul Stackhouse, Mohan Shankar, J. Robert Mahan, Alexander Halterman
**Collaborator:** Norman Loeb
**Partners:** Science Systems and Applications Inc., Quartus Engineering Incorporated, NovaWurks Inc., Virginia Tech.

## Key Milestones

| | |
|---|---|
| • Project Kick-off | 01/20 |
| • Requirements Definitions Complete | 03/20 |
| • Downselection of optical architecture | 05/20 |
| • Preliminary Development Review | 02/21 |
| • Long-Lead Procurement Spec Complete | 07/21 |
| • Critical Development Review | 01/22 |
| • Assembly Integration and Test Complete | 08/22 |
| • Project Close-Out Review | 12/22 |

$TRL_{in} = 2$ $TRL_{out} = 4$

ESTO Earth Science Technology Office